M-C Power Commercialization Program Overview

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Introduction:

Since its incorporation in 1987, M-C Power has focused on development and integration of molten carbonate fuel cell technology by combining individual cells into cost-effective stacks, which are then integrated into a power plant system utilizing commercially available balance of plant equipment. Demonstration testing of cogeneration power plant concepts that generate electric power and steam in practical applications at the desired capacity level are an integral part of our commercialization strategy.

We have successfully operated increasingly larger fuel cell stacks while improving power output and cell life. Development activities include the improvement of component performance, endurance tests, and cost reduction methods. This work represents an important milestone in M-C Power's commercialization program and has culminated in the design, construction, and testing of a fully integrated 250-kW molten carbonate fuel cell (MCFC) power plant at the Naval Air Station (NAS) Miramar in San Diego, California.

The purpose of the Product Development Test (PDT) at the NAS Miramar was to demonstrate the internally manifolded heat exchanger (IMHEX®) MCFC technology in a thermally integrated power plant. This project has provided the data required to finalize the commercial design for M-C Power's market entry product. The findings from the PDT project are currently being incorporated into our Product Design and Improvement (PDI) project. This paper addresses the importance of the PDI program in commercializing MCFC technology by the year 2001 and M-C Power's approach to achieving that goal.

Objective:

The objective of the PDI project is to establish commercial readiness of M-C Power's MCFC system for distributed generation and other applications. To date, work performed under this project has focused on quantifying the market potential for MCFC technology, recognizing and addressing the requirements of the customer base, and resolving cost reduction and technical issues affecting the marketability, performance, and reliability of MCFC power plant systems. M-C Power's ongoing commercialization program is enhanced by recent development activities and market studies.

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When M-C Power was founded, its initial mission was to develop, produce, and commercialize a high efficiency, environmentally benign energy conversion device based on a molten carbonate fuel cell utilizing the IMHEX® design. Today, our corporate goal reflects the many accomplishments we've made since our founding. We plan to enter the market with nominal 250-kW and 1-MW flexible and modular power plant products. We based this decision upon several factors which include market studies completed in the past year; input from members of the Alliance to Commercialize Carbonate Technology (ACCT), which includes their views of the future in a deregulated marketplace; analysis and recommendations of the commercialization team members; and the results of the demonstration test at the NAS Miramar. A great deal of the technology development work has been completed. The remaining barriers have been identified and a strategy has been implemented. We have production capabilities established—and we've set our sights on accomplishing the full scale commercialization of this technology.

Approach

The approach for developing this technology was defined early on when M-C Power established a commercialization team in order to succeed at meeting its mission. The commercialization team is comprised of major players in the fields of energy research, power plant design, packaging, distribution, and maintenance. It is led by M-C Power and is balanced out by Stewart & Stevenson Services, Bechtel Corporation, and the Institute of Gas Technology. This team provides the expertise needed to develop and commercialize a cost-effective power plant based on M-C Power's molten carbonate fuel cell MCFC stack technology.

Although M-C Power is managing the commercialization and development of the MCFC technology, the contributions of its supporting team members and their significance can't be overlooked. The Institute of Gas Technology is responsible for component development to increase cell performance and endurance. M-C Power then takes this technology and scales it up to commercial size utilizing its proven manufacturing processes. Bechtel Corporation provides the process design for the overall plant and the detailed design of the systems needed to support the fuel cell stacks and form a completely integrated operational power plant. Stewart & Stevenson Services receives the specified equipment, packages it on transportable skids that are completed with piping, instrumentation, and wiring. The skids are then factory tested to verify performance and operational characteristics.

Verification tests and power plant efforts within the Product Design and Improvement project are directed toward the construction and operation of a prototype power plant system. The system is intended to reflect all of the design and operational features of the market entry product. The commercialization team has developed a strategic approach to implementation of the project. This approach capitalizes on past development projects and enables the team to accelerate its efforts to

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satisfy our commercialization objective through the successful design, manufacture, field test, and evaluation of the prototype power plant.

Project Description

The commercialization team has chartered the best course of action in order to achieve the highest probability of success. The performance of market assessments and product definition activities was the first order of business under this project. They are discussed in further detail in the results portion of this paper. They have led to a framework from which the system design and analysis tasks could proceed in a timely fashion. Bechtel had previously selected a baseline system which they have been using to perform trade-off studies. The results of these studies are discussed in the following section.

The other major areas covered under the PDI program include the optimization of the manufacturing processes developed in an earlier program and verification of advanced component concepts. Optimization and automation of active cell component manufacturing processes, consolidation of separator plate manufacturing, and the upgrading of our QA/QC capabilities are all serving to enhance our ability to produce quality stacks for prototype power demonstrations.

Through the identification, qualification, and implementation of advanced component formulations and manufacturing processes, we are reducing the cost of producing the cells that comprise the fuel cell stack. We have been developing, verifying, and improving upon the critical components and subsystems required in a market responsive product. Efforts are focusing on the cell package, stack module, and balance-of-plant components.

Future testing will be carried out using existing facilities. Modification will be made to these facilities as deemed appropriate by the commercialization team and its sponsors. Tests are being performed to verify advanced engineering designs and component technologies. Balance of plant components have been identified and will be qualified through strategic vendor alliances. These verification efforts will be focusing on the turbogenerator, recycle blower, and power conditioning units. All subsystems and BOP components will be accepted only after rigorous factory endurance verification. Fuel processing is addressing a variety of alternate fuels.

Results

The results of the PDI program to date have contributed to a better understanding of the markets for MCFC technology. Those results are discussed further in the application section of this paper.

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Market analysis completed over the past year has led to a detailed product definition and realignment of our program strategy to reflect the dynamics of a changing market.

Bechtel has been charged with the task of developing simple and cost effective concepts for nominal 250-kW and 1-MW class power plants. The decision to further explore the opportunities of a power plant with the capacity of 250-kW has been purely market driven. The members of ACCT and other industry players have expressed their interest in a power plant of this size, and we have responded. From early on they have conveyed the importance of reliability, durability and cost. We have been working to address those issues from the onset of our development program.

The path to allowable installed power plant cost (stack and balance of plant) has been established. Stack costs are being reduced by elimination and integration of processing steps, design simplification, and the use of low cost raw materials. Many of these cost reduction approaches are currrently being tested at the 100 cm^2 single cell scale and in 1000 cm^2 stacks. The cost of the balance of plant is being reduced by compaction, component elimination, and system simplification.

Applications

More recently, the markets for this technology have been driven by the issues surrounding deregulation and competition in the electric industry. Some of the issues driving the market for fuel cell technology include retaining loads through better customer service, environmental regulations, power quality, reliability, constrained capital for utility transmission and distribution (T&D) investments, and distributed vs. centralized power generation. Our market analysis gives us a clearer understanding of these issues and their impact on the PDI program.

The target market within the United States can be segmented into four main areas. They are commercial applications, light industrial applications, distributed power, and several special niche applications. The commercial segment includes small to medium sized hospitals, hotels schools, and shopping malls. For these applications our technology would serve as a co-generation unit; supplying heat and electricity for cooling and illumination. The light industrial segment includes, but is not limited to, the chemical, paper, metal, food, and plastics industries. In this application, the MCFC would serve as a co-generator of electrical power and high quality steam to serve the respective industrial processes.

The customers for the distributed power segment would include the traditional utilities and their unregulated subsidiaries. The main driver behind this application is the avoidance or deferral of T&D costs. The MCFC would alleviate energy losses within the system, supply reactive power support, and defer the construction of costlier system upgrades.

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The special niche segment includes applications such as computer centers that require premium power quality and high reliability. Also within this segment are producers of opportunity fuels such as landfills, waste water treatment plants, and refineries. In these applications the MCFC will help them to lower current power costs by using available waste streams as fuel.

Future Activities

M-C Power and the commercialization team will continue with the tasks outlined under the PDI program. The most important element in the near term is to integrate and verify that the balance of plant components can perform reliably. Concurrently, we will expand upon our accomplishments in the area of cell performance and cost reduction.

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